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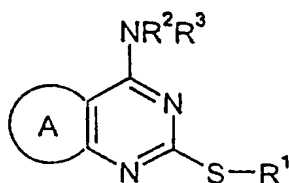
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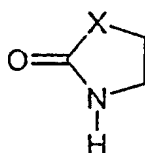
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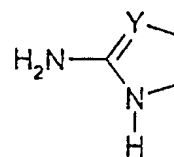
(54) Title: PYRIMIDINE COMPOUNDS AND THEIR USE AS MODULATORS OF CHEMOKINE RECEPTOR ACTIVITY



(I)



(a)



(b)

(57) Abstract: The invention provides certain heterocyclic compounds, processes and intermediates used in their preparation, pharmaceutical compositions containing them and their use in therapy; in formula (I), A is a group of formula (a) or (b).

## PYRIMIDINE COMPOUNDS AND THEIR USE AS MODULATORS OF CHEMOKINE RECEPTOR ACTIVITY

The present invention relates to certain heterocyclic compounds, processes and intermediates used in their preparation, pharmaceutical compositions containing them and their use in therapy.

Chemokines play an important role in immune and inflammatory responses in various diseases and disorders, including asthma and allergic diseases, as well as autoimmune pathologies such as rheumatoid arthritis and atherosclerosis. These small secreted molecules are a growing superfamily of 8-14 kDa proteins characterised by a conserved four cysteine motif. At the present time, the chemokine superfamily comprises three groups exhibiting characteristic structural motifs, the C-X-C, C-C and C-X<sub>3</sub>-C families. The C-X-C and C-C families have sequence similarity and are distinguished from one another on the basis of a single amino acid insertion between the NH-proximal pair of cysteine residues. The C-X<sub>3</sub>-C family is distinguished from the other two families on the basis of having a triple amino acid insertion between the NH-proximal pair of cysteine residues.

The C-X-C chemokines include several potent chemoattractants and activators of neutrophils such as interleukin-8 (IL-8) and neutrophil-activating peptide 2 (NAP-2).

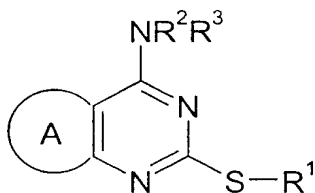
The C-C chemokines include potent chemoattractants of monocytes and lymphocytes but not neutrophils. Examples include human monocyte chemotactic proteins 1-3 (MCP-1, MCP-2 and MCP-3), RANTES (Regulated on Activation, Normal T Expressed and Secreted), eotaxin and the macrophage inflammatory proteins 1 $\alpha$  and 1 $\beta$  (MIP-1 $\alpha$  and MIP-1 $\beta$ ).

The C-X<sub>3</sub>-C chemokine (also known as fractalkine) is a potent chemoattractant and activator of microglia in the central nervous system (CNS) as well as of monocytes, T cells, NK cells and mast cells.

Studies have demonstrated that the actions of the chemokines are mediated by subfamilies of G protein-coupled receptors, among which are the receptors designated CCR1, CCR2, CCR2A, CCR2B, CCR3, CCR4, CCR5, CCR6, CCR7, CCR8, CCR9, CCR10 and CCR11 (for the C-C family); CXCR1, CXCR2, CXCR3, CXCR4 and CXCR5 (for the C-X-C family) and CX<sub>3</sub>CR1 for the C-X<sub>3</sub>-C family. These receptors represent good targets for

drug development since agents which modulate these receptors would be useful in the treatment of disorders and diseases such as those mentioned above.

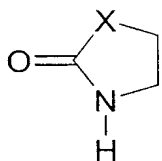
The present invention therefore provides compounds of formula (I) and pharmaceutically acceptable salts or solvates thereof:



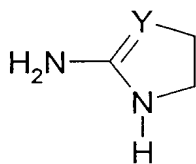
(I)

in which:

A is a group of formula (a) or (b):



(a)



(b)

R¹ represents a C<sub>3</sub>-C<sub>7</sub> carbocyclic, C<sub>1</sub>-C<sub>8</sub> alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl or C<sub>2</sub>-C<sub>6</sub> alkynyl group, the latter four groups may be optionally substituted by one or more substituent groups independently selected from halogen atoms, -OR<sup>4</sup>, -NR<sup>5</sup>R<sup>6</sup>, -CONR<sup>5</sup>R<sup>6</sup>, -COOR<sup>7</sup>, -NR<sup>8</sup>COR<sup>9</sup>, -SR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, -SO<sub>2</sub>NR<sup>5</sup>R<sup>6</sup>, -NR<sup>8</sup>SO<sub>2</sub>R<sup>10</sup>, an aryl or heteroaryl group either of which can be optionally substituted by one or more substituents independently selected from halogen atoms, cyano, nitro, -OR<sup>4</sup>, -NR<sup>5</sup>R<sup>6</sup>, -CONR<sup>5</sup>R<sup>6</sup>, -COOR<sup>7</sup>, -NR<sup>8</sup>COR<sup>9</sup>, -SR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, -SO<sub>2</sub>NR<sup>5</sup>R<sup>6</sup>, -NR<sup>8</sup>SO<sub>2</sub>R<sup>10</sup>, C<sub>1</sub>-C<sub>6</sub> alkyl or trifluoromethyl groups;

$R^2$  and  $R^3$  each independently represent hydrogen, a  $C_3$ - $C_7$  carbocyclic group,  $C_1$ - $C_8$  alkyl,  $C_2$ - $C_6$  alkenyl or  $C_2$ - $C_6$  alkynyl group, the latter four groups may be optionally substituted by one or more substituent groups independently selected from

5 halogen atoms,  $-OR^4$ ,  $-NR^5R^6$ ,  $-CONR^5R^6$ ,  $-COOR^7$ ,  $-NR^8COR^9$ ,  $-SR^{10}$ ,  $-SO_2R^{10}$ ,  $-SO_2NR^5R^6$ ,  $-NR^8SO_2R^{10}$

or

$R^2$  and  $R^3$  together form a 3-8 membered ring optionally containing one or more atoms selected from O, S,  $NR^8$  and itself optionally substituted by  $C_{1,3}$ -alkyl, halogen,

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$R^4$  represents hydrogen,  $C_1$ - $C_6$  alkyl or a phenyl group the latter two of which may be optionally substituted by one or more substituent groups independently selected from halogen atoms, phenyl,  $-OR^{11}$  and  $-NR^{12}R^{13}$ ;

15  $R^5$  and  $R^6$  independently represent a hydrogen atom or a  $C_1$ - $C_6$  alkyl or phenyl group the latter two of which may be optionally substituted by one or more substituent groups independently selected from halogen atoms, phenyl,  $-OR^{14}$  and  $-NR^{15}R^{16}$ ,  $-CONR^{15}R^{16}$ ,  $-NR^{15}COR^{16}$ ,  $-SO_2NR^{15}R^{16}$ ,  $NR^{15}SO_2R^{16}$

or

20  $R^5$  and  $R^6$  together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring system optionally comprising a further heteroatom selected from oxygen and nitrogen atoms, which ring system may be optionally substituted by one or more substituent groups independently selected from phenyl,  $-OR^{14}$ ,  $-COOR^{14}$ ,  $-NR^{15}R^{16}$ ,  $-CONR^{15}R^{16}$ ,  $-NR^{15}COR^{16}$ ,  $-SO_2NR^{15}R^{16}$ ,  $NR^{15}SO_2R^{16}$  or  $C_1$ - $C_6$  alkyl, itself  
25 optionally substituted by one or more substituents independently selected from halogen atoms and  $-NR^{15}R^{16}$  and  $-OR^{17}$  groups;

$R^{10}$  represents a  $C_1$ - $C_6$  alkyl group or phenyl group, each of which may be optionally substituted by one or more substituent groups independently selected from halogen atoms,  
30 phenyl,  $-OR^{17}$  and  $-NR^{15}R^{16}$ ;

X is NH or  $CR^{18}R^{19}$ ;

Y is N or  $CR^{18}$ ; and

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each of  $R^7$ ,  $R^8$ ,  $R^9$ ,  $R^{11}$ ,  $R^{12}$ ,  $R^{13}$ ,  $R^{14}$ ,  $R^{15}$ ,  $R^{16}$ ,  $R^{17}$ ,  $R^{18}$ ,  $R^{19}$  independently represent a hydrogen atom,  $C_1$ - $C_6$ , alkyl, or a phenyl group.

In the context of the present specification, unless otherwise indicated, an alkyl or alkenyl group or an alkyl or alkenyl moiety in a substituent group may be linear or branched.

Aryl groups include phenyl and naphthyl. Heteroaryl is defined as a 5- or 6-membered aromatic ring optionally containing one or more heteroatoms selected from N, S, O. Examples include pyridine, pyrimidine, thiazole, oxazole, pyrazole, imidazole, furan. Heterocyclic rings as defined for  $R^5$  and  $R^6$  means saturated heterocycles, examples of which include morpholine, azetidine, pyrrolidine, piperidine and piperazine.

Certain compounds of formula (I) are capable of existing in stereoisomeric forms. It will be understood that the invention encompasses all geometric and optical isomers of the compounds of formula (I) and mixtures thereof including racemates. Tautomers and mixtures thereof also form an aspect of the present invention.

In formula (I) above, A represents a sub-group of formula (a) or (b). Preferably A is a group of formula (b) and Y is N.

Suitably the group  $R^1$  represents a  $C_3$ - $C_7$  carbocyclic,  $C_1$ - $C_8$  alkyl,  $C_2$ - $C_6$  alkenyl or  $C_2$ - $C_6$  alkynyl group, the latter four groups may be optionally substituted by one or more substituent groups independently selected from halogen atoms,  $-OR^4$ ,  $-NR^5R^6$ ,  $-CONR^5R^6$ ,  $-COOR^7$ ,  $-NR^8COR^9$ ,  $-SR^{10}$ ,  $-SO_2R^{10}$ ,  $-SO_2NR^5R^6$ ,  $-NR^8SO_2R^{10}$ , an aryl or heteroaryl group each of which can be optionally substituted by one or more substituents independently selected from halogen atoms, cyano, nitro,  $-OR^4$ ,  $-NR^5R^6$ ,  $-CONR^5R^6$ ,  $-COOR^7$ ,  $-NR^8COR^9$ ,  $-SR^{10}$ ,  $-SO_2R^{10}$ ,  $-SO_2NR^5R^6$ ,  $-NR^8SO_2R^{10}$ ,  $C_1$ - $C_6$  alkyl or trifluoromethyl groups.

Particularly advantageous compounds of formula (I) are those in which  $R^1$  represents an optionally substituted benzyl group. More preferably  $R^1$  represents benzyl or benzyl substituted by one or more halogen atoms, in particular benzyl substituted by two fluorine atoms.

Suitably  $R^2$  and  $R^3$  each independently represent hydrogen, a  $C_3$ - $C_7$  carbocyclic group,  $C_1$ - $C_8$  alkyl,  $C_2$ - $C_6$  alkenyl or  $C_2$ - $C_6$  alkynyl group, the latter four groups may be optionally substituted by one or more substituent groups independently selected from

halogen atoms,  $-OR^4$ ,  $-NR^5R^6$ ,  $-CONR^5R^6$ ,  $-COOR^7$ ,  $-NR^8COR^9$ ,  $-SR^{10}$ ,  $-SO_2R^{10}$ ,  $-SO_2NR^5R^6$ ,  $-NR^8SO_2R^{10}$ , or  $R^2$  and  $R^3$  together form a 3-8 membered ring optionally containing one or more atoms selected from O, S,  $NR^8$  and itself optionally substituted by  $C_{1-3}$ -alkyl, halogen.

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Preferably one of  $R^2$  and  $R^3$  is hydrogen and the other is  $C_3$ - $C_8$  alkyl substituted by one or more hydroxy groups. More preferably one of  $R^2$  and  $R^3$  is hydrogen and the other is  $CH(CH_3)CH_2OH$ ,  $CH(Et)CH_2OH$ ,  $C(CH_3)_2CH_2OH$  or  $CH(CH_2OH)_2$ . When one of  $R^2$  and  $R^3$  is hydrogen and the other is  $CH(CH_3)CH_2OH$  or  $CH(Et)CH_2OH$  the resulting  
 10 compounds of formula (I) are preferably in the form of the (R) isomer. Most preferably one of  $R^2$  and  $R^3$  is hydrogen and the other is  $CH(CH_3)CH_2OH$ .

Particularly preferred compounds of the invention include:

2-[[[(2,3-Difluorophenyl)methyl]thio]-5,7-dihydro-4-[(1*R*)-2-hydroxy-1-  
 15 methylethyl]amino]-6*H*-pyrrolo[2,3-*d*]pyrimidin-6-one,  
 7,9-dihydro-6-[(1*R*)-2-hydroxy-1-methylethyl]amino]-2-[(phenylmethyl)thio]-8*H*-purin-8-one,  
 4-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-5,7-dihydro-6*H*-pyrrolo[2,3-*d*]pyrimidin-6-one,  
 20 (2*R*)-2-[[[8-amino-2-[[[(2-fluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1,3-propanediol,  
 2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-2-methyl-1-propanol,  
 (2*R*)-2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-butanol,  
 25 2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-2-methyl-1,3-propanediol,  
 (2*R*)-2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-ethanol,  
 (2*R*)-2-[[[8-amino-2-[[[(3-chlorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 30 (2*R*)-2-[[[8-amino-2-[(phenylmethyl)thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 (2*R*)-2-[[[8-amino-2-[[[(3-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 (2*R*)-2-[[[8-amino-2-[[[(2-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 (2*R*)-2-[[[8-amino-2-[[[(3-methoxyphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
 (2*R*)-2-[[[8-amino-2-[[[(4-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

(2*R*)-2-[[8-amino-2-[[2-bromophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

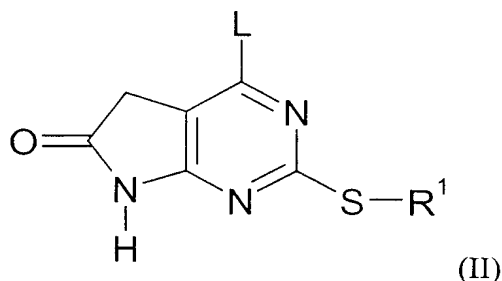
(2*R*)-2-[[8-amino-2-[[3-chloro-2-fluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

(2*R*)-2-[[8-amino-2-[[3-chloro-4-methoxyphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

(2*R*)-2-[[8-amino-2-[(1,3-benzodioxol-4-yl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol, and pharmaceutically acceptable salts and solvates thereof.

According to the invention there is also provided a process for the preparation of:-

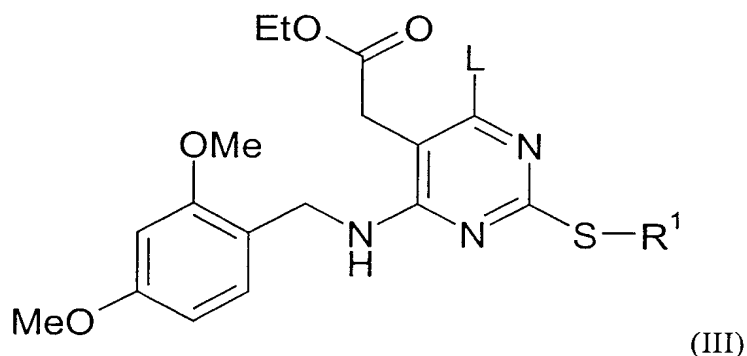
(a) a compound of formula (I) where A is a sub-group of formula (a) and X is CH<sub>2</sub> which comprises treatment of a compound of formula (II):



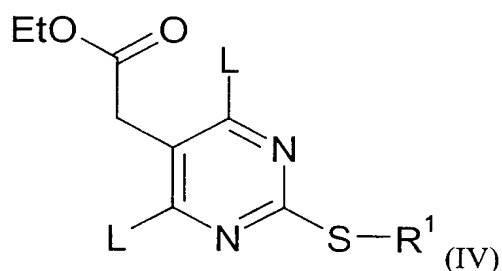
where R<sup>1</sup> is as defined in formula (I) and L is a leaving group such as chlorine with an amine HNR<sup>2</sup>R<sup>3</sup> and optionally forming a pharmaceutically acceptable salt. The reaction can be carried out in a solvent such as N-methylpyrrolidinone at elevated temperature, for example at between 0°C and 150°C.

Compounds of formula (II) where R<sup>1</sup> is as defined in formula (I) and L is a halogen may be prepared by heating a compound of formula (III) where R<sup>1</sup> is as defined above and L is a halogen in the presence of an acid catalyst such as p-toluene sulphonic acid. The reaction can be carried out in a solvent such as toluene at elevated temperature, for example at reflux.

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Compounds of formula (III) where  $R^1$  is as defined in formula (I) and L is a halogen may be prepared by treating a compound of formula (IV) where  $R^1$  is as defined above and L is a halogen with 2,4-dimethoxybenzylamine in the presence of a base such as *N,N*-diisopropylethylamine. The reaction may be carried out in a solvent such as dimethylformamide between 0°C and 100°C.

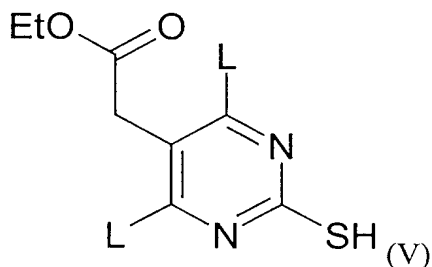


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Compounds of formula (IV) where  $R^1$  is as defined in formula (I) and L is a halogen may be prepared by treating a compound of formula (IV) where  $R^1$  is as defined in formula (I) and L is an hydroxyl group with a halogenating agent such as phosphorus oxychloride. The reaction may be carried out at reflux in the presence of dimethylaniline.

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Compounds of formula (IV) where  $R^1$  is as defined in formula (I) and L is an hydroxyl group are suitably prepared by reacting a compound of formula (V):



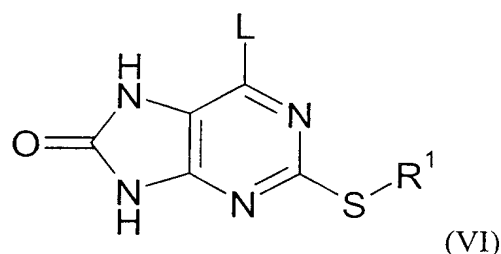
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with a compound of formula  $R^1X$  where  $R^1$  is as defined above and X is a leaving group such as bromide in the presence of a base such as sodium hydride. The reaction may be carried out in a solvent such as dimethylformamide at room temperature.

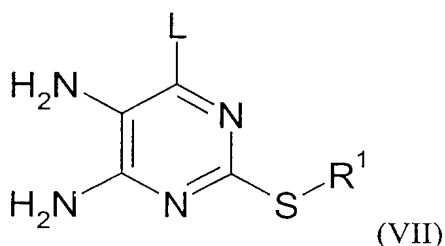
- 5 The compound of formula (V) where L is a hydroxyl group may be suitably prepared by treating 1,1,2-ethane tricarboxylate with thiourea in the presence of a base such as sodium ethoxide. The reaction may be carried out in a solvent such as ethanol at reflux.

- (b) a compound of formula (I) where A is a sub-group of formula (a) and X is NH which  
10 comprises treatment of a compound of formula (VI):

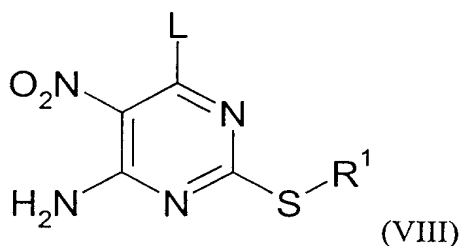


- where  $R^1$  is as defined in formula (I) and L is a leaving group such as chlorine with an  
15 amine  $HNR^2R^3$  and optionally forming a pharmaceutically acceptable salt. The reaction can be carried out in a solvent such as N-methylpyrrolidinone at elevated temperature, for example at between  $0^\circ\text{C}$  and  $150^\circ\text{C}$ .

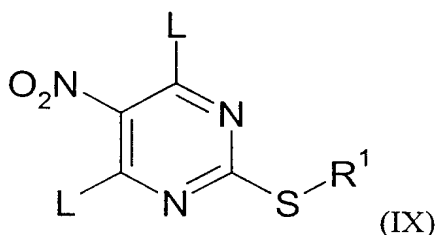
- Compounds of formula (VI) where  $R^1$  is as defined in formula (I) and L is a leaving group  
20 such as chlorine may be prepared from compounds of formula (VII) where  $R^1$  and L are as defined above by treatment with phosgene or an equivalent reagent such as triphosgene. The reaction may be carried out in a solvent such as dichloromethane in the presence of a base such as triethylamine at room temperature or below.



Compounds of formula (VII) where  $R^1$  is as defined in formula (I) and L is a leaving group such as chlorine may be prepared from compounds of formula (VIII) where  $R^1$  and L are as defined above by treatment with a reducing agent such as iron. The reaction may be carried out in a solvent such as aqueous ethanol in the presence of ammonium chloride at a temperature between 0°C and 100°C.

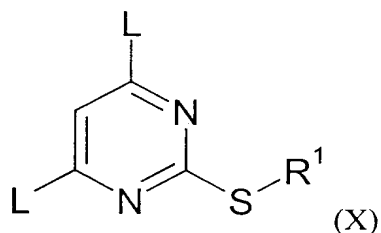


Compounds of formula (VIII) where  $R^1$  is as defined in formula (I) and L is a leaving group such as chlorine may be prepared from compounds of formula (IX) where  $R^1$  and L are as defined above by treatment with ammonia. The reaction may be carried out in a solvent such as tetrahydrofuran in the presence of a base such as diisopropylamine at a temperature between 0°C and 100°C.

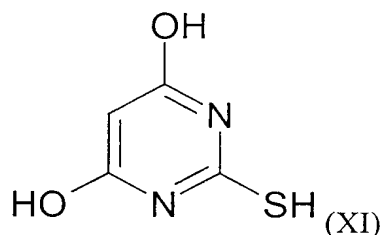


Compounds of formula (IX) where  $R^1$  is as defined in formula (I) and L is a leaving group such as chlorine may be prepared from compounds of formula (IX) where  $R^1$  is as defined in formula (I) and L is hydroxy by treatment with a halogenating agent such as phosphorus oxychloride. The reaction may be carried out in the presence of a base such as 1-methylimidazole at a temperature between 0°C and 150°C.

Compounds of formula (IX) where  $R^1$  is as defined in formula (I) and L is hydroxy may be prepared from compounds of formula (X) where  $R^1$  is as defined in formula (I) and L is hydroxy by treatment with a nitrating agent such as concentrated nitric acid. The reaction may be performed in a solvent such as glacial acetic acid at a temperature between 0°C and 150°C.

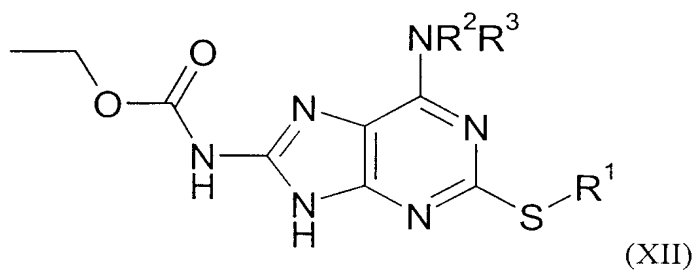


Compounds of formula (X) where R<sup>1</sup> is as defined in formula (I) and L is hydroxy may be prepared from compounds of formula (XI) by treatment with a compound of formula R<sup>1</sup>X where R<sup>1</sup> is as defined above and X is a leaving group such as bromide. The reaction may be carried out in a solvent such as aqueous NMP using a base such as sodium hydroxide at room temperature.



(c) a compound of formula (I) where A is a sub-group of formula (b) and Y is N which comprises either:-

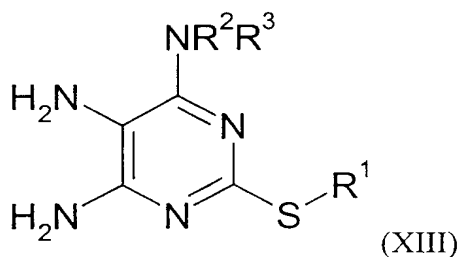
i) treatment of a compound of formula (XII):



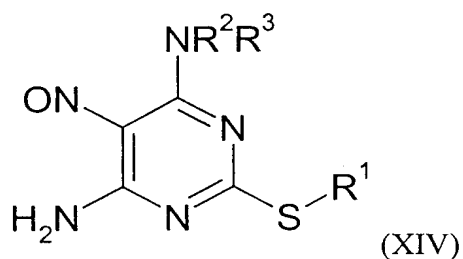
where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined in formula (I) with a hydrolysing agent such as lithium hydroxide. The reaction may be performed in a solvent such as aqueous dioxan at a temperature between 0°C and 100°C.

Compounds of formula (XII) where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined in formula (I) may be prepared by treatment of compounds of formula (XIII) with ethoxycarbonylthiocyanate

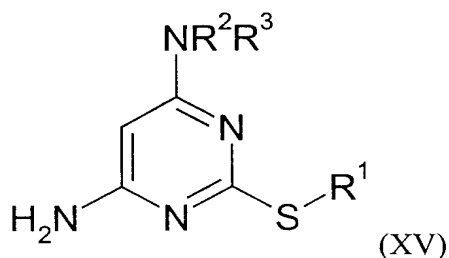
followed by a dehydrating agent such as diisopropylcarbodiimide. The reaction may be carried out in a solvent such as acetonitrile at a temperature between 0°C and 100°C.



Compounds of formula (XIII) where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined in formula (I) may be prepared by treatment of compounds of formula (XIV) where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined above with a reducing agent such as sodium dithionite. The reaction may be performed in a solvent such as aqueous DMF at a temperature between 0°C and 150°C.

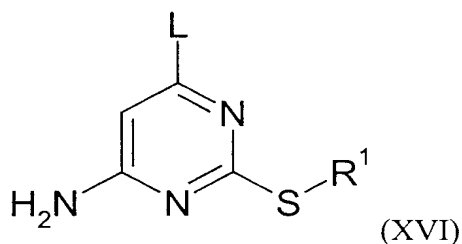


Compounds of formula (XIV) where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined in formula (I) may be prepared by treatment of compounds of formula (XV) where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined above with a nitrosating agent such as sodium nitrite in acetic acid. The reaction may be conveniently carried out at room temperature.



Compounds of formula (XV) where R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined in formula (I) may be prepared by treatment of compounds of formula (XVI) where R<sup>1</sup> is as defined in formula (I) and L is a leaving group such as chloro with an amine HNR<sup>2</sup>R<sup>3</sup>. The reaction can be

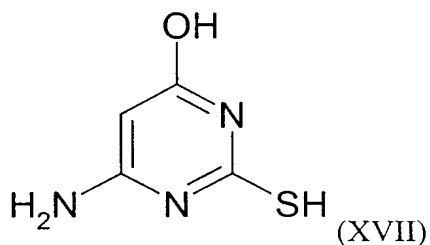
carried out in a solvent such as N-methylpyrrolidinone at elevated temperature, for example at between 50°C and 200°C.



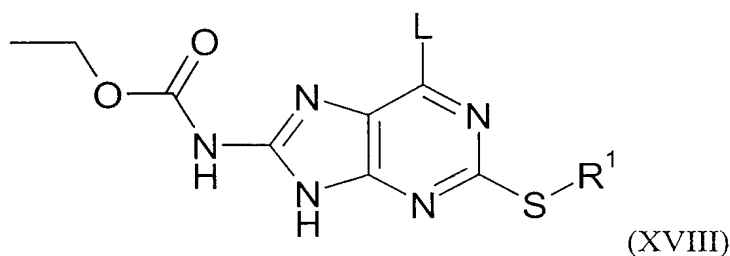
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Compounds of formula (XVI) where R<sup>1</sup> is as defined in formula (I) and L is a leaving group such as chloro may be prepared by treatment of compounds of formula (XVI) where R<sup>1</sup> is as defined in formula (I) and L is hydroxy by treatment with a halogenating agent such as phosphorus oxychloride. The reaction may be carried out in the presence of a base  
10 such as 2-picoline at a temperature between 0°C and 150°C.

Compounds of formula (XVI) where R<sup>1</sup> is as defined in formula (I) and L is hydroxy may be prepared from compounds of formula (XVII) by treatment with a compound of formula R<sup>1</sup>X where R<sup>1</sup> is as defined above and X is a leaving group such as bromide. The reaction  
15 may be carried out in a solvent such as aqueous DMF using a base such as potassium hydroxide at room temperature.



20 ii) treatment of a compound of formula (XVIII):



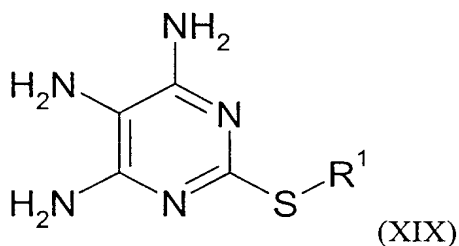
where  $R^1$  is as defined in formula (I) and L is a leaving group such as bromine with an amine  $HNR^2R^3$ . The reaction can be carried out in a solvent such as N-methylpyrrolidinone at elevated temperature, for example at between  $50^\circ\text{C}$  and  $200^\circ\text{C}$ .

- 5 Compounds of formula (XVIII) where  $R^1$  is as defined in formula (I) and L is a leaving group such as bromine may be prepared from compounds of formula (XVIII) where  $R^1$  is as defined above and L is  $NH_2$  by treatment with a diazotizing agent such as isoamyl nitrite in the presence of a halogenating agent such as bromoform. The reaction may be performed at a temperature between  $0^\circ\text{C}$  and  $100^\circ\text{C}$ .

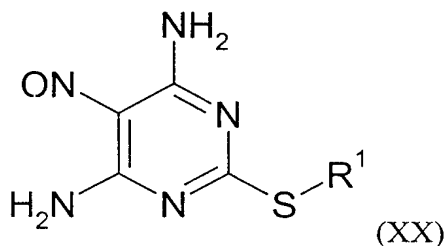
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Compounds of formula (XVIII) where  $R^1$  is as defined in formula (I) and L is  $NH_2$  may be prepared from compounds of formula (XIX) where  $R^1$  is as defined above by treatment with ethoxycarbonylisothiocyanate followed by a dehydrating agent such as diisopropylcarbodiimide. The reaction may be carried out in a solvent such as acetonitrile

15



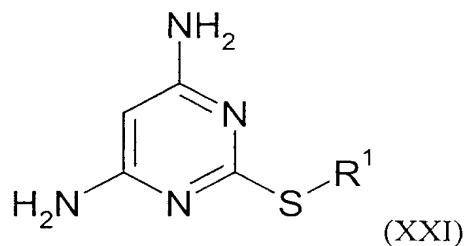
- 20 Compounds of formula (XIX) where  $R^1$  is as defined in formula (I) may be prepared from compounds of formula (XX) where  $R^1$  is as defined above by treatment with a reducing agent such as sodium hydrosulphite. The reaction may be carried out in a solvent such as water at reflux.



25

Compounds of formula (XX) where  $R^1$  is as defined in formula (I) may be prepared by treatment of compounds of formula (XXI) where  $R^1$  is as defined above with a nitrosating

agent such as sodium nitrite. The reaction may be performed in a solvent such as aqueous acetic acid at a temperature between 0°C and 100°C.

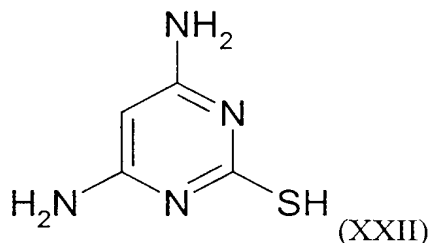


5

Compounds of formula (XXI) where R<sup>1</sup> is as defined in formula (I) may be prepared from compounds of formula (XXII) by treatment with a compound of formula R<sup>1</sup>X where R<sup>1</sup> is as defined above and X is a leaving group such as bromide. The reaction may be carried out in a solvent such as aqueous DMF using a base such as potassium hydroxide at room

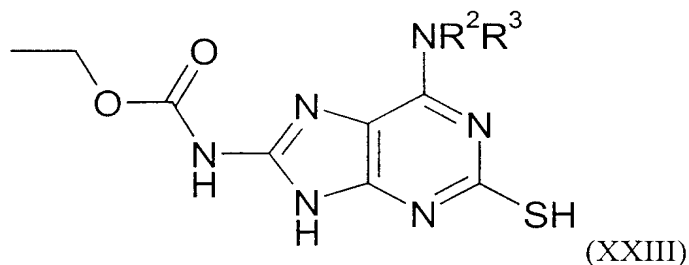
10

temperature.



iii) treatment of a compound of formula (XXIII):

15

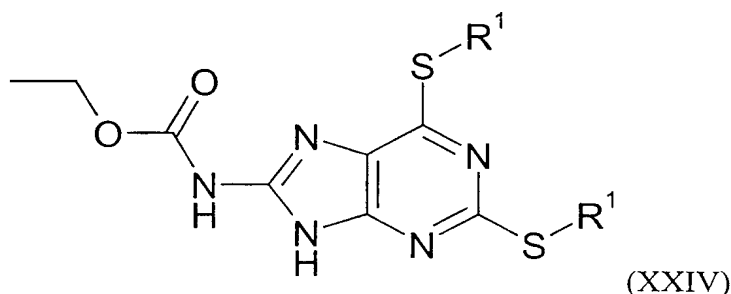


where R<sup>2</sup> and R<sup>3</sup> are as defined in formula (I) with a compound of formula R<sup>1</sup>X where R<sup>1</sup> is as defined in formula (I) followed by treatment with a hydrolysing agent such as lithium hydroxide. The alkylation reaction may be performed in a solvent such as DMSO at a temperature between 0°C and 100°C, and the hydrolysis in a solvent such as aqueous dioxan at reflux.

20

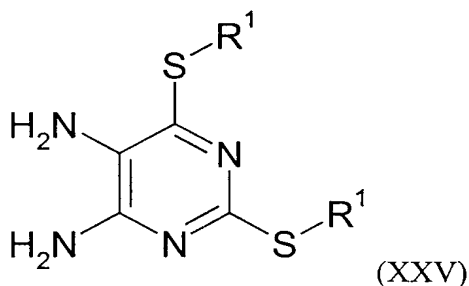
Compounds of formula (XXIII) where  $R^2$  and  $R^3$  are as defined in formula (I) may be prepared by treatment of a compound of formula (XII) where  $R^1$ ,  $R^2$  and  $R^3$  are as defined in formula (I) with sodium in liquid ammonia.

iv) treatment of a compound of formula (XXIV):



where  $R^1$  is as defined in formula (I) with an amine  $HNR^2R^3$ . The reaction can be carried out in the absence of solvent at elevated temperature, for example between  $100^\circ\text{C}$  and  $200^\circ\text{C}$ .

Compounds of formula (XXIV) where  $R^1$  is as defined in formula (I) may be prepared by treatment of a compound of formula (XXV) where  $R^1$  is as defined above with ethoxycarbonylthiocyanate followed by a dehydrating agent such as diisopropylcarbodiimide. The reaction may be carried out in a solvent such as acetonitrile at a temperature between  $0^\circ\text{C}$  and  $100^\circ\text{C}$ .

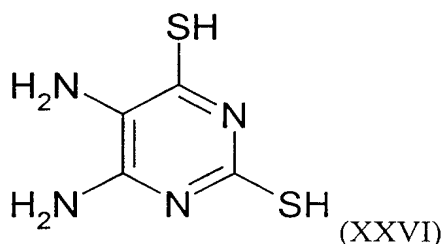


20

Compounds of formula (XXV) where  $R^1$  is as defined in formula (I) may be prepared from compounds of formula (XXVI) by treatment with a compound of formula  $R^1X$  where  $R^1$  is as defined above and  $X$  is a leaving group such as bromide. The reaction may be carried out in a solvent such as methanol using a base such as potassium hydroxide at room temperature.

25





Compounds of formula (XI), (XVII), (XXII) and (XXVI) are commercially available.

5 It will be appreciated by those skilled in the art that in the processes of the present invention certain functional groups such as hydroxyl or amino groups in the starting reagents or intermediate compounds may need to be protected by protecting groups. Thus, the preparation of the compounds of formula (I) may involve, at an appropriate stage, the removal of one or more protecting groups. The protection and deprotection of functional  
10 groups is fully described in 'Protective Groups in Organic Chemistry', edited by J. W. F. McOmie, Plenum Press (1973), and 'Protective Groups in Organic Synthesis', 2nd edition, T. W. Greene & P. G. M. Wuts, Wiley-Interscience (1991).

Novel intermediate compounds form a further aspect of the invention.

15

The compounds of formula (I) above may be converted to a pharmaceutically acceptable salt or solvate thereof, preferably an acid addition salt such as a hydrochloride, hydrobromide, phosphate, acetate, fumarate, maleate, tartrate, citrate, oxalate, methanesulphonate or *p*-toluenesulphonate, or a basic addition salt such as sodium,  
20 potassium, calcium, aluminium, lithium, magnesium, zinc, benzathine, chlorprocaine, choline, diethanolamine, ethanolamine, ethyldiamine, meglumine, tromethamine or procaine.

The compounds of formula (I) have activity as pharmaceuticals, in particular as modulators  
25 of chemokine receptor (especially CXCR2) activity, and may be used in the treatment (therapeutic or prophylactic) of conditions/diseases in human and non-human animals which are exacerbated or caused by excessive or unregulated production of chemokines. Examples of such conditions/diseases include:

30

- (1) **(the respiratory tract)** obstructive airways diseases including chronic obstructive pulmonary disease (COPD); asthma, such as bronchial, allergic, intrinsic, extrinsic and dust asthma, particularly chronic or inveterate asthma

- (e.g. late asthma and airways hyper-responsiveness); bronchitis; acute, allergic, atrophic rhinitis and chronic rhinitis including rhinitis caseosa, hypertrophic rhinitis, rhinitis purulenta, rhinitis sicca and rhinitis medicamentosa; membranous rhinitis including croupous, fibrinous and pseudomembranous rhinitis and scrofulous rhinitis; seasonal rhinitis including rhinitis nervosa (hay fever) and vasomotor rhinitis; sarcoidosis, farmer's lung and related diseases, fibroid lung and idiopathic interstitial pneumonia;
- 5
- (2) **(bone and joints)** rheumatoid arthritis, seronegative spondyloarthropathies (including ankylosing spondylitis, psoriatic arthritis and Reiter's disease), Behcet's disease, Sjogren's syndrome and systemic sclerosis;
- 10
- (3) **(skin)** psoriasis, atopic dermatitis, contact dermatitis and other eczematous dermatides, seborrhoetic dermatitis, Lichen planus, Pemphigus, bullous Pemphigus, Epidermolysis bullosa, urticaria, angiodermas, vasculitides, erythemas, cutaneous eosinophilias, uveitis, Alopecia areata and vernal conjunctivitis;
- 15
- (4) **(gastrointestinal tract)** Coeliac disease, proctitis, eosinophilic gastro-enteritis, mastocytosis, Crohn's disease, ulcerative colitis, food-related allergies which have effects remote from the gut, e.g., migraine, rhinitis and eczema;
- 20
- (5) **(central and peripheral nervous system)** Neurodegenerative diseases and dementia disorders, e.g. Alzheimer's disease, amyotrophic lateral sclerosis and other motor neuron diseases, Creutzfeldt-Jacob's disease and other prion diseases, HIV encephalopathy (AIDS dementia complex), Huntington's disease, frontotemporal dementia, Lewy body dementia and vascular dementia; polyneuropathies, e.g. Guillain-Barré syndrome, chronic inflammatory demyelinating polyradiculoneuropathy, multifocal motor neuropathy, plexopathies; CNS demyelination, e.g. multiple sclerosis, acute disseminated/haemorrhagic encephalomyelitis, and subacute sclerosing panencephalitis; neuromuscular disorders, e.g. myasthenia gravis and Lambert-Eaton syndrome; spinal disorders, e.g. tropical spastic paraparesis, and stiff-man
- 25
- 30

syndrome: paraneoplastic syndromes, e.g. cerebellar degeneration and encephalomyelitis; CNS trauma; migraine; and stroke.

- (6) **(other tissues and systemic disease)** atherosclerosis, Acquired  
5 Immunodeficiency Syndrome (AIDS), lupus erythematosus, systemic lupus, erythematosus, Hashimoto's thyroiditis, type I diabetes, nephrotic syndrome, eosinophilia fascitis, hyper IgE syndrome, lepromatous leprosy, and idiopathic thrombocytopenia pupura; post-operative adhesions, and sepsis.
- 10 (7) **(allograft rejection)** acute and chronic following, for example, transplantation of kidney, heart, liver, lung, bone marrow, skin and cornea; and chronic graft versus host disease;
- (8) Cancers, especially non-small cell lung cancer (NSCLC), malignant melanoma,  
15 prostate cancer and squamous sarcoma, and tumour metastasis;
- (9) Diseases in which angiogenesis is associated with raised CXCR2 chemokine levels (e.g. NSCLC, diabetic retinopathy).
- 20 (10) Cystic fibrosis, re-perfusion injury in the heart, brain, peripheral limbs and other organs.
- (11) Burn wounds & chronic skin ulcers
- 25 (12) Reproductive Diseases (e.g. Disorders of ovulation, menstruation and implantation, Pre-term labour, Endometriosis)

Thus, the present invention provides a compound of formula (I), or a pharmaceutically-acceptable salt or solvate thereof, as hereinbefore defined for use in therapy.

30

Preferably the compounds of the invention are used to treat diseases in which the chemokine receptor belongs to the CXC chemokine receptor subfamily, more preferably the target chemokine receptor is the CXCR2 receptor,

Particular conditions which can be treated with the compounds of the invention are psoriasis, diseases in which angiogenesis is associated with raised CXCR2 chemokine levels, and COPD. It is preferred that the compounds of the invention are used to treat psoriasis.

5

As a further aspect of the present invention, certain compounds of formula (I) may have utility as antagonists of the CX3CR1 receptor. Such compounds are expected to be particularly useful in the treatment of disorders within the central and peripheral nervous system and other conditions characterized by an activation of microglia and/or infiltration of leukocytes (e.g. stroke/ischemia and head trauma).

10

In a further aspect, the present invention provides the use of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for use in therapy.

15

In a still further aspect, the present invention provides the use of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for the treatment of human diseases or conditions in which modulation of chemokine receptor activity is beneficial.

20

In the context of the present specification, the term "therapy" also includes "prophylaxis" unless there are specific indications to the contrary. The terms "therapeutic" and "therapeutically" should be construed accordingly.

25

The invention still further provides a method of treating a chemokine mediated disease wherein the chemokine binds to a chemokine (especially CXCR2) receptor, which comprises administering to a patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined.

30

The invention also provides a method of treating an inflammatory disease, especially psoriasis, in a patient suffering from, or at risk of, said disease, which comprises administering to the patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined.

35

For the above-mentioned therapeutic uses the dosage administered will, of course, vary with the compound employed, the mode of administration, the treatment desired and the disorder indicated.

5 The compounds of formula (I) and pharmaceutically acceptable salts and solvates thereof may be used on their own but will generally be administered in the form of a pharmaceutical composition in which the formula (I) compound/salt/solvate (active ingredient) is in association with a pharmaceutically acceptable adjuvant, diluent or carrier. Depending on the mode of administration, the pharmaceutical composition will preferably  
10 comprise from 0.05 to 99 %w (per cent by weight), more preferably from 0.05 to 80 %w, still more preferably from 0.10 to 70 %w, and even more preferably from 0.10 to 50 %w, of active ingredient, all percentages by weight being based on total composition.

The present invention also provides a pharmaceutical composition comprising a compound  
15 of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined, in association with a pharmaceutically acceptable adjuvant, diluent or carrier.

The invention further provides a process for the preparation of a pharmaceutical composition of the invention which comprises mixing a compound of formula (I), or a  
20 pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined, with a pharmaceutically acceptable adjuvant, diluent or carrier.

The pharmaceutical compositions may be administered topically (e.g. to the lung and/or  
25 airways or to the skin) in the form of solutions, suspensions, heptafluoroalkane aerosols and dry powder formulations; or systemically, e.g. by oral administration in the form of tablets, capsules, syrups, powders or granules, or by parenteral administration in the form of solutions or suspensions, or by subcutaneous administration or by rectal administration in the form of suppositories or transdermally. Preferably the compounds of the invention are administered orally.

30 The invention will now be further illustrated by reference to the following examples. In the examples the Nuclear Magnetic Resonance (NMR) spectra were measured on a Varian Unity Inova 300 or 400 MHz spectrometer and the Mass Spectrometry (MS) spectra measured on a Finnigan Mat SSQ7000 or Micromass Platform spectrometer. Where  
35 necessary, the reactions were performed under an inert atmosphere of either nitrogen or argon. Chromatography was generally performed using Matrex Silica 60<sup>®</sup> (35-70 micron)

or Prolabo Silica gel 60<sup>®</sup> (35-70 micron) suitable for flash silica gel chromatography. High pressure liquid chromatography purification was performed using either a Waters Micromass LCZ with a Waters 600 pump controller, Waters 2487 detector and Gilson FC024 fraction collector or a Waters Delta Prep 4000. The abbreviations m.p. and DMSO used in the examples stand for melting point and dimethyl sulphoxide respectively.

### Example 1

#### **2-[[[(2,3-Difluorophenyl)methyl]thio]-5,7-dihydro-4-[(1*R*)-2-hydroxy-1-methylethyl]amino]- 6*H*-pyrrolo[2,3-*d*]pyrimidin-6-one**

##### **(a) 4,6-Dihydroxy-2-mercapto-5-pyrimidineacetic acid, ethyl ester**

To a solution of sodium ethoxide [prepared from sodium metal (1.6g) and ethanol] was added thiourea (5.28g) and triethyl 1,1,2-ethane tricarboxylate (17g). The mixture was heated under reflux for 8 hours. The solution was cooled to room temperature and the solid collected by filtration, washed with a little ether. The solid was dissolved in water (100 ml) and the pH adjusted to 6-7 by the addition of hydrochloric acid. No solid was precipitated therefore the solution was lyophilised to give a pink solid (8.1g)

<sup>1</sup>H NMR: δ (DMSO) 10.79 (2H, s), 3.97 (2H, q), 3.06 (2H, s), 1.14 (3H, t).

##### **(b) 2-[[[(2,3-Difluorophenyl)methyl]thio]-4,6-dihydroxy-5-pyrimidineacetic acid, ethyl ester**

To a suspension of 60% sodium hydride in oil (1.37g) in dry DMF (10 ml) was added a solution of the product from example 1, step (a) (7.9g) in dry DMF (30 ml). After the addition the mixture was stirred at room temperature for 1 hour. To the solution was added 2,3-difluorobenzylbromide (4.45 ml) and the mixture allowed to stir overnight. The mixture was poured into water (200 ml) and the product collected by filtration to give the subtitle compound (8.1g).

MS: APCI 355 (M-H), 357 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 7.50-7.18 (3H, m), 4.47 (2H, s), 4.04 (2H, q), 3.97 (2H, s), 1.67 (3H, t).

##### **(c) 4,6-Dichloro-2-[[[(2,3-difluorophenyl)methyl]thio]- 5-pyrimidineacetic acid, ethyl ester**

A mixture of the product from example 1, step (b) (8.1g) and phosphorus oxychloride (100 ml) was stirred at room temperature while *N,N*-dimethylaniline (2.91 ml) was added dropwise. The solution was then heated under reflux for 2 hours. The mixture was allowed to cool to room temperature and poured onto crushed ice/water. The crude product was  
5 extracted into ether. Chromatography on silica eluting with 10% methanol/isohexane afforded the subtitle compound (5.1g).

MS: APCI 392 (M-H), 394 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 7.32-6.98 (3H, m), 4.43 (2H, s), 4.23 (2H, q), 3.87 (2H, s), 1.28 (3H,  
10 t).

**(d) 4-Chloro-2-[[[(2,3-difluorophenyl)methyl]thio]-6-[[[(2,4-dimethoxyphenyl)methyl]amino]- 5-pyrimidineacetic acid, ethyl ester**

To a solution of the product from example 1, step (c) (1.0g) in dry DMF (30 ml) was added 2,4-dimethoxybenzylamine hydrochloride (0.52g) followed by *N,N'*-diisopropylethylamine  
15 (1 ml) and the mixture stirred at 40°C for 1 hour. The mixture was evaporated to dryness. Chromatography on silica eluting with 10% ethyl acetate/dichloromethane afforded the subtitle compound (1.0g).

MS: APCI 522 (M-H), 524 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 7.28-7.22 (1H, m), 7.13-6.97 (3H, m), 6.45-6.42 (2H, m), 6.08 (1H,  
20 t), 4.57 (2H, s), 4.41 (2H, s), 4.16 (2H, q), 3.82 (3H, s), 3.79 (3H, s), 3.54 (2H, s), 1.22 (3H, t).

**(e) 4-Chloro-2-[[[(2,3-difluorophenyl)methyl]thio]-5,7-dihydro-6*H*-pyrrolo[2,3-  
25 *d*]pyrimidin-6-one,**

A solution of the product from example 1, step (d) (0.5g) in dry toluene (50 ml) containing *p*-toluene sulphonic acid (25 mg) was heated under reflux for 4 hours. [Analysis of the reaction mixture by lc/ms indicated cyclisation was complete but with loss of the acid labile dimethoxybenzyl adduct.] The reaction mixture was evaporated to dryness and the  
30 residue purified by chromatography on silica eluting with ethyl acetate to afford the subtitle compound (0.20g).

MS: APCI 328 (M+H)

**(f) 2-[[2,3-Difluorophenyl)methyl]thio]-5,7-dihydro-4-[(1*R*)-2-hydroxy-1-methylethyl]amino]- 6*H*-pyrrolo[2,3-*d*]pyrimidin-6-one**

The product from example 1, step (e) (0.20g) in NMP (5 ml) was treated with  
5 (R)-2-amino-1-propanol (0.56g) and the reaction mixture was heated at 110°C for 2 hours. The mixture was evaporated to dryness and the residue purified (HPLC, Symmetry® C18 column, 0.1% aqueous ammonium acetate:acetonitrile isocratic elution 75:25) to afford the title compound (0.055g).

10 MS: APCI 367 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 7.38-7.10 (3H, m), 6.74 (1H, d), 4.69 (1H, m), 4.38 (2H, s), 4.12 (1H, m), 3.43-3.29 (2H, m), 3.17 (2H, s), 1.08 (3H, d).

**Example 2**

15 **7,9-dihydro-6-[(1*R*)-2-hydroxy-1-methylethyl]amino]-2-[(phenylmethyl)thio]-8*H*-purin-8-one**

**a) 2-[(Phenylmethyl)thio]-4,6-pyrimidinediol**

20 To a solution of 4,6-dihydroxy-2-mercaptopyrimidine (100 g) in 5M NaOH (360 ml) was added first NMP (200 ml), then benzyl bromide (90 ml) dropwise over 2 hours. The reaction was stirred at room temperature for 24 hours, then acidified to pH 2 with conc HCl (100 ml) added dropwise over 2 hours at -5°C to give a pink precipitate. This was isolated  
25 by decanting off the solution followed by trituration with diethyl ether (1 litre) to give the subtitled product as a white powder after filtration and drying (210 g).

m.p. 220-250°C (dec)

MS: APCI (-ve) 233 (M-H)

30 <sup>1</sup>H NMR: δ (DMSO) 11.76 (1H, br s), 7.45 (2H, d), 7.26 (3H, m), 5.18 (1H, s), 4.38 (2H, s).

**b) 5-Nitro-2-[(phenylmethyl)thio]-4,6-pyrimidinediol**

35 The product of example 2, step (a) (2 g) was added to a mixture of glacial acetic acid (50 ml) and concentrated nitric acid (20 ml) and the reaction mixture heated to 50°C. A further



28 g of the product of step (a) was added in portions over 2 hours whilst maintaining the reaction temperature between 50 and 60°C. After stirring the reaction mixture for a further 1 hour at 50°C it was poured onto crushed ice and the subtitled product isolated by filtration as a yellow solid (12.3 g).

5

<sup>1</sup>H NMR: δ (DMSO) 7.48-7.19 (5H, m), 4.47 (2H, s).

**c) 4,6-Dichloro-5-nitro-2-[(phenylmethyl)thio]-pyrimidine**

10 A suspension of the product of example 2, step (b) ( 59.2 g) in a mixture of POCl<sub>3</sub> (100 ml) and toluene (400 ml) was heated to 80°C. A solution of 1-methylimidazole (16.9 ml) in toluene (200 ml) was added dropwise over 1 hour and the reaction mixture then heated at 100°C for 24 hours. After cooling to room temperature, the solvent was removed by evaporation and water (2 litres) cautiously added to the residue. The mixture was extracted  
15 with dichloromethane (4x500 ml) and the combined organic extracts dried over MgSO<sub>4</sub>, filtered and evaporated to give a brown tar. This was purified by column chromatography, eluting with 10% dichloromethane in isohexane, to afford the subtitled product as a yellow solid (29.7 g).

20 MS: APCI (-ve) 315 (M-H)

<sup>1</sup>H NMR: δ (DMSO) 7.43-7.24 (5H, m), 4.40 (2H, s).

**d) 6-chloro-5-nitro-2-[(phenylmethyl)thio]-4-pyrimidinamine**

25 Ammonia solution (14 ml, 0.5 M in dioxane) was added dropwise to a solution of the product of example 2, step (c) (2.0 g) and diisopropylethylamine (3.31 ml) in THF (100 ml) over a 1 h period at RT. After stirring for a further 1 h the reaction was concentrated *in vacuo* onto silica and purified by column chromatography using 9:1 then 4:1 isohexane / ethyl acetate as eluent to yield the subtitled product as a yellow solid (980 mg, 52 %).

30

MS: ESI (-ve) 296 (M-H, 100 %)

**e) 6-chloro-2-[(phenylmethyl)thio]-4,5-pyrimidinediamine**

35 A suspension of the product from example 2, step (d) (980 mg), NH<sub>4</sub>Cl (1.61 g) and iron powder (559 mg) in EtOH (100 ml) and H<sub>2</sub>O (15 ml) was heated at 85 °C for 1.5 h. The

mixture was filtered through celite and washed with hot MeOH (100 ml) before concentrating the filtrate onto silica under reduced pressure. Column chromatography using 1:1 isohexane / ethyl acetate as eluent provided the subtitled product as a yellow solid (0.69 g, 78 %)

5

MS: ESI (-ve) 265 (M-H, 100 %)

**f) 6-chloro-7,9-dihydro-2-[(phenylmethyl)thio]-8H-purin-8-one**

10 A solution of triphosgene (0.92 g) in DCM (25 ml) was added dropwise to a solution of the product from example 2, step (e) (0.69 g) and triethylamine (0.55 ml) in DCM (25 ml) at -10 °C. The cooling bath was then removed and the suspension stirred for 2.5 h. Upon cooling to 0 °C NaHCO<sub>3</sub> (20 ml) was added with vigorous stirring before recovering the organics by extracting with DCM (3 x 50 ml). The organic extracts were combined, dried  
15 (MgSO<sub>4</sub>) and concentrated *in vacuo* to yield a crude yellow solid. This material was triturated with EtOAc and filtered to afford a pink solid (360 mg, 48 %). The filtrate was concentrated and again triturated with EtOAc to provide a second crop (170 mg, 70 % overall)

20 MS: ESI (-ve) 291 (M-H, 100 %)

**g) 7,9-dihydro-6-[(1*R*)-2-hydroxy-1-methylethyl]amino]-2-[(phenylmethyl)thio]-8H-purin-8-one**

25 A solution of the product from example 2, step (f) (0.1 g) in a mixture of alaninol (0.128 g), diisopropylethylamine (0.35 ml) and *N*-methylpyrrolidinone (3 ml) was stirred at 100 °C for 48 h before pouring into H<sub>2</sub>O (75 ml). 2M HCl solution was then added to pH = 2 and the light brown solid formed filtered and recrystallised from EtOH to afford the subtitle compound (22 mg, 19 %)

30

m.p. 284 °C

MS: ESI (-ve) 330 (M-H, 100 %)

<sup>1</sup>H NMR: δ (DMSO) 11.2 (1H, s), 9.82 (1H, s), 7.20-7.41 (5H, m), 6.40 (1H, d, *J* 10.8), 4.85 (2H, s), 4.30 (2H, s), 4.15 (1H, m), 3.43 (2H, m) and 1.14 (3H, d, *J* 7.4)

35

**Example 3**

**4-amino-2-[[ (2,3-difluorophenyl)methyl]thio]-5,7-dihydro-6H-pyrrolo[2,3-*d*]pyrimidin-6-one,**

5 (a) **4-amino-5,7-dihydro-2-mercapto-6H-pyrrolo[2,3-*d*]pyrimidin-6-one,**

Prepared by the method of example 1, step (a), using 3,3-dicyano-propanoic acid, ethyl ester.

10 MS: APCI 183 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 11.76 (1H, s), 10.97 (1H, s), 6.89 (2H, s), 3.23 (2H, s).

**(b) 4-amino-2-[[ (2,3-difluorophenyl)methyl]thio]-5,7-dihydro-6H-pyrrolo[2,3-*d*]pyrimidin-6-one,**

15 To a suspension of 60% sodium hydride (125mg) in dry DMF (5 ml) was added a solution of the product from example 3, step (a) (0.57g) in DMF (10 ml). The mixture was allowed to stir for 30 mins. To the solution was added 2,3-difluorobenzyl bromide (0.39 ml) and the mixture stirred for 2 hours. Poured into water and the crude product extracted into ethyl acetate. Chromatography on silica eluting with 10% ethyl acetate/dichloromethane  
20 afforded the title compound (0.35g).

MS: APCI 309 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 10.85 (1H, s), 7.45-10 (3H, m), 6.78 (2H, m), 4.36 (2H, s), 3.24 (2H, s).

25

**Example 4**

**(2*R*)-2-[[8-amino-2-[[ (2-fluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,**

30 (a) **6-amino-2-[[ (2-fluorophenyl)methyl]thio]-4-pyrimidinol,**

To a stirred suspension of 4-Amino-6-hydroxy-2-mercaptopyrimidine monohydrate (25g) in DMF (300ml) was added potassium hydroxide (10.2g) and water (50ml). After a clear solution was obtained, 2-fluorobenzyl bromide (29.3g) was added and the reaction stirred

at room temperature for 30min. The mixture was poured into water (2l) and the resulting precipitate isolated by filtration, washing with isopropanol and diethyl ether, affording the subtitled compound as a white solid (34.7g).

5 MS: APCI 252 (M+H)

<sup>1</sup>H NMR: δ (DMSO) 11.42 (1H, br s), 7.61 (1H, t), 7.33 (1H, m), 7.16 (2H, m), 6.56 (2H, br s), 4.97 (1H, s), 4.35 (2H, s).

**(b) 6-chloro-2-[[2-(2-fluorophenyl)methyl]thio]-4-pyrimidinamine**

10

The product of example 4, step (a) (34g) was added to a solution of 2-picoline (20ml) in POCl<sub>3</sub> (150ml) and the mixture refluxed for 24hr. The reaction mixture was concentrated *in vacuo* to half its original volume and poured onto ice and then neutralized with ammonia, forming a brown gum. The aqueous phase was decanted off, and the organic residues  
15 dissolved in ethyl acetate. This solution was recombined with the aqueous phase, and refluxed for 1hr. The organic phase was separated, evaporated, and the residue purified by silica gel chromatography, eluting with dichloromethane to afford the subtitled compound as a pale yellow solid (15.6g).

20 MS: APCI (+ve) 270 (M+H, 100 %)

<sup>1</sup>H NMR: δ (DMSO) 7.57 (1H, t), 7.37 (2H, br s), 7.33 (1H, m), 7.14 (2H, m), 6.20 (1H, s), 4.32 (2H, s).

**(c) (2R)-2-[[6-amino-2-[[2-(2-fluorophenyl)methyl]thio]-4-pyrimidinyl]amino]-1-propanol**

25

A solution of the product from example 4, step (b) (15g), triethylamine (15ml) and D-alaninol (10g) was heated at 160°C for 18h. The reaction mixture was allowed to cool to room temperature and poured into aqueous ammonium chloride (1l). The resultant white  
30 precipitate was purified by silica gel chromatography, eluting first with 1:1 DCM:ethyl acetate and then 3:1 DCM:methanol, giving the subtitled product as a yellow foam (10.7g).

MS: APCI (+ve) 309 (M+H, 100 %)

**(d) (2R)-2-[[6-amino-2-[[2-(2-fluorophenyl)methyl]thio]-5-nitroso-4-pyrimidinyl]amino]-1-propanol**

35

To a stirred solution of the product from example 4, step (c) (10g) in acetic acid (300ml) at room temperature was added a solution of sodium nitrite (2.24g) in water (30ml). The reaction was stirred at 0°C for 30min, and the resultant purple precipitate isolated by  
5 filtration, washing with water, to give the subtitled compound as a dark blue solid (4.8g).

MS: APCI (+ve) 338 (M+H, 100 %)

10 **(e) (2R)-2-[[5,6-diamino-2-[(2-fluorophenyl)methyl]thio]-4-pyrimidinyl]amino]-1-propanol**

Sodium dithionite (4g) was added in portions to a suspension of the product from example 4, step (d) (8.4g) in a mixture of water (35ml) and DMF (15ml) at 100°C. The resultant yellow solution was cooled in an ice bath and 50% aqueous sulphuric acid (15ml) was  
15 added, giving a grey precipitate. The mixture was stirred for 10min, then filtered, washing with water, ethanol and diethyl ether, to afford the subtitled product as a grey solid (1.0g).

MS: APCI (+ve) 324 (M+H, 100 %)

20 **(f) [2-[(2-fluorophenyl)methyl]thio]-6-[(1R)-2-hydroxy-1-methylethyl]amino]-9H-purin-8-yl]-carbamic acid, ethyl ester**

To a solution of ethoxycarbonylthiocyanate (0.48ml) in dry acetonitrile (20ml) at 0°C under an atmosphere of nitrogen was added a suspension of the product from example 4, step (e) (1.15g) in dry acetonitrile (20ml) containing 2.5eq triethylamine. After stirring at  
25 0°C for 5min, diisopropylcarbodiimide (0.8ml) was added and the reaction warmed to 70°C for 1hr. The reaction mixture was concentrated *in vacuo* and the residue purified twice by silica gel chromatography, eluting both times with 3:1 ethyl acetate:DCM, to afford the subtitled product as a white solid (0.045g).

30

MS: APCI (+ve) 421 (M+H, 100 %)

<sup>1</sup>H NMR: δ (DMSO) 11.87 (1H, br s), 11.41 (1H, br s), 7.56 (2H, m), 7.28 (1H, m), 7.14 (2H, m), 4.81 (1H, t), 4.36 (2H, s), 4.22 (3H, m), 3.46 (1H, m), 3.39 (1H, m), 1.28 (3H, t), 1.15 (3H, d).

35

**(g) (2R)-2-[[8-amino-2-[(2-fluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-1-**

**propanol**

A solution of the product from example 4, step (f) (0.042g) and lithium hydroxide monohydrate (16mg) in dioxan (4ml) and water (2ml) was heated under reflux for 5hr. The reaction mixture was concentrated *in vacuo* and the residue purified by silica gel column chromatography, eluting with 4:1 DCM:ethanol containing 0.5% 880 ammonia, to afford the titled compound as a white solid (0.015g).

m.p. 250-255°C (dec)

MS: APCI (+ve) 349 (M+H, 100 %)

<sup>1</sup>H NMR: δ (DMSO) 10.30 (1H, br s), 7.54 (1H, t), 7.28 (1H, m), 7.14 (2H, m), 6.64 (1H, br s), 6.47 (1H, br s), 4.77 (1H, br s), 4.34 (2H, s), 4.17 (1H, m), 3.45 (1H, m), 3.38 (1H, m), 1.13 (3H, d).

**Example 5****2-[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-1,3-propanediol****a) 2-[[[(2,3-Difluorophenyl)methyl]thio]- 4,6-pyrimidinediamine**

4,6-diamino-2-pyrimidinethiol (7.3g) was dissolved in DMSO (100ml) at room temperature under an atmosphere of nitrogen. Potassium *tert*-butoxide (1M in THF, 48.3ml) was added followed by 2,3-difluorobenzyl-bromide (10.0g). The mixture was stirred for 2 hours at room temperature. The reaction mixture was then partitioned between ethyl acetate and ammonium chloride. The organic phase was washed with ammonium chloride (3x) and brine, then dried over magnesium sulphate and evaporated to give the subtitled product as a white solid (12.2g)

MS: APCI (+ve) 269 (M+1)

**b) 2-[[[(2,3-Difluorophenyl)methyl]thio]-5-nitroso-4,6-pyrimidinediamine**

The product of example 5, step (a) (2.5g) was dissolved in acetic acid (150ml) and the solution cooled to 5°C. A solution of sodium nitrite (625mg) in water (50ml) was added dropwise resulting in a dark blue colouration. The reaction was stirred at room temperature

for 30 minutes during which time a pink solid precipitated from solution. This was isolated by filtration and washed with water, then dried at 50°C to give the sub-titled product as a blue solid (4.14g)

5 MS: APCI (+ve) 298 (M+1)

<sup>1</sup>H NMR: δ (DMSO) 4.44 (s, 2H), 7.13-7.54 (m, 3H), 8.13 (s, 1H), 8.51 (s, 1H), 9.10 (s, 1H), 10.18 (s, 1H).

**c) 2-[[[(2,3-Difluorophenyl)methyl]thio]- 4,5,6-pyrimidinetriamine**

10

To a suspension of the product of example 5, step (b) (2g) in boiling water (40ml) was added Na<sub>2</sub>S<sub>2</sub>O<sub>4</sub> (5.4g) portion-wise. The suspension was allowed to cool and then 50% sulphuric acid was added slowly and then the mixture was cooled to 0°C. The solid was isolated by filtration and washed with cold water, then dried over P<sub>2</sub>O<sub>5</sub> at 50°C to give the  
15 sub-titled product as a yellow solid.

MS: APCI (+ve) 284 (M+1)

<sup>1</sup>H NMR: δ (DMSO) 4.33 (s, 2H), 6.42 (br s, 3H), 7.10-7.48 (m, 3H)

20 **d) Ethyl 6-amino-2-[(2,3-difluorobenzyl)thio]-9H-purin-8-ylcarbamate**

A solution of the product of example 5, step (c) (10.5g) in acetonitrile (50ml) and triethylamine (17ml) was added to an ice cold stirred solution of ethoxycarbonylthiocyanate (3ml) in acetonitrile (50ml). This mixture was then stirred at  
25 room temperature for 20min. Diisopropylcarbodiimide (4.5ml) was then added and the reaction mixture was stirred at reflux for 2hr and allowed to cool. The reaction mixture was evaporated to dryness and purified by flash chromatography on silica gel (ethyl acetate:dichloromethane, 1:1) to yield the sub-titled compound as a yellow solid (3.0g).

30 MS: APCI (+ve) 381 (M+1)

**e) Ethyl 6-bromo-2-[(2,3-difluorobenzyl)thio]-9H-purin-8-ylcarbamate**

35 The product of example 5, step (d) (1g) was dissolved in bromoform (14ml) and iso-amyl nitrite (0.1ml) and heated at 40°C for 5hr. The reaction mixture was then evaporated to

dryness and purified by flash chromatography on silica gel with 20% ethyl acetate in dichloromethane, yielding the subtitled compound as a yellow solid (208mg).

MS: APCI (+ve) 445 (M+1)

5

**f) 2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-1,3-propanediol**

The product of example 5, step (e) (40mg) was dissolved in NMP and 2-amino-1,3-propanediol (49.2mg) and diisopropylethylamine (31μl) base was added and the solution was heated at 150°C for 36hr. The reaction mixture was then evaporated to a residue that was purified by preparative HPLC to yield the titled compound as a pale yellow solid (9.5mg).

MS: APCI (+ve) 383 (M+1)

<sup>1</sup>H NMR: δ (DMSO) 3.52 (m, 4H), 4.17 (m, 1H), 4.41 (s, 2H), 4.78 (m, 2H), 7.13-7.45 (m, 3H), 7.59 (m, 1H).

**Example 6**

20

**2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-2-methyl-1-propanol**

The titled compound was prepared from the product of example 5, step (e) (50mg) and 2-amino-2-methyl-1-propanol (66μl) using the method of example 5, step (f) and purified by preparative HPLC to yield a white solid.

MS: APCI (+ve) 381 (M+1)

<sup>1</sup>H NMR: δ (DMSO) 0.98 (s, 6H), 3.13 (s, 2H), 3.49 (s, 1H), 4.39 (s, 2H), 6.48 (br s, 1H), 7.13-7.37 (m, 3H).

30

**Example 7**

**(2R)-2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-1-butanol**

35



The titled compound was prepared from the product of Example 5, step (e) (50mg) and (2*R*)-2-amino-1-butanol (66μl) using the method of example 5, step (f) and purified by preparative HPLC to yield a white solid.

5 MS: APCI (+ve) 381 (M+1)

<sup>1</sup>H NMR: δ (CDCl<sub>3</sub>) 0.89 (m, 3H), 1.55-1.73 (m, 2H), 3.27 (m, 1H), 3.57 (m, 1H), 3.65 (m, 1H), 4.16 (m, 1H), 4.44 (s, 2H), 5.39 (br s, 2H), 5.73 (d, 1H), 6.97-7.34 (m, 3H).

### Example 8

10

#### **2-[[8-amino-2-[[2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-2-methyl-1,3-propanediol**

15 The titled compound was prepared from the product of example 5, step (e) (50mg) and 2-amino-2-methyl-1,3-propanediol (70mg) using the method of example 5, step (f) and purified by preparative HPLC to yield a white solid.

MS: APCI (+ve) 397 (M+1)

20 <sup>1</sup>H NMR: δ (DMSO) 7.37-7.11 (3H, m), 4.38 (2H, s), 3.63 (2H, d), 3.53 (2H, d), 1.25 (3H, s)

### Example 9

#### **(2*R*)-2-[[8-amino-2-[[2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol**

25

##### **a) 2,6-bis[[2,3-difluorophenyl)methyl]thio]-4,5-pyrimidinediamine**

30 5,6-diamino-2,4-pyrimidinedithiol (10.9g, 62.6mmol) was dissolved in a solution of KOH powder (85%) (7.72g, 2.2eq) in methanol (250ml). 2,3-difluorobenzyl bromide (22.5g, 1.75eq) was added and the mixture was stirred at room temperature for 30min. The resulting solution was poured in to 500ml of water, whereupon a pale brown solid precipitated out which was collected by filtration and washed with 3x iso-propanol and 3x ether to give the subtitled product as a pale brown solid (15g, 56%) which was dried in a  
35 vacuum oven.

MS: APCI (+ve) 427 (M+1)

**b) [2,6-bis[[[(2,3-difluorophenyl)methyl]thio]-9H-purin-8-yl]-, ethyl ester carbamic acid**

5

A solution of the product of example 9, step (a) (23g) in hot acetonitrile (500ml) was added to an ice-cold solution of ethoxycarbonyl isothiocyanate (7.6ml, 1.2eq) in acetonitrile (250ml) and stirred at 0°C for 30min. Diisopropylcarbodiimide (12.6ml, 1.5eq) was then added and the reaction mixture was refluxed for 2hr. The mixture was then cooled and the brown precipitate that formed was collected by filtration, washed with acetonitrile and ether and air dried to yield the sub-titled compound as a brown solid (20.5g, 73%).

MS: APCI (+ve) 524 (M+1)  
<sup>1</sup>H NMR: δ (DMSO) 1.26 (t,3H), 4.22 (q,2H), 4.49 (s,2H), 4.59 (s,2H), 7.12-7.48 (m,6H), 11.44 (bs,1H), 12.38 (bs,1H).

15

**c) (2R)-2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-1-propanol**

20

The product of example 9, step (b) (5x1g) was dissolved in hot D-alaninol (5x3ml) in a sealed tube (5x10ml capacity) and heated to 200°C for 24hr. The resulting solutions were combined and evaporated. The residue was purified first by flash chromatography on silica, eluting with ethyl acetate:methanol 10:1 (+0.5% 880 ammonia) followed by preparative HPLC to yield the titled product as a white solid (72mg, 2%).

25

MS: APCI (+ve) 367 (M+1)  
<sup>1</sup>H NMR: δ (DMSO) 1.13 (d,3H), 3.41 (m,2H), 4.17 (m,1H), 4.37 (s,2H), 4.79 (bs,1H), 7.09-7.37 (m,3H).

30

**Example 10**

**2-[[[8-amino-2-[[[(2,3-difluorophenyl)methyl]thio]-9H-purin-6-yl]amino]-ethanol**

The titled compound was prepared from the product of example 9, step (b) (3g) and ethanolamine (9ml) using the method of example 9, step (c).

35

MS: APCI (+ve) 353 (M+1)

<sup>1</sup>H NMR: δ (DMSO) 3.47 (s,2H), 3.55 (m,2H), 4.38 (s,2H), 4.79 (s,1H), 7.09-7.37 (m,3H).

5    **Example 11**

**(2R)-2-[[8-amino-2-[[[(3-chlorophenyl)methyl]thio]-9H-purin-6-yl]amino]-1-propanol**

**(a) 6-amino-2-[[[(3-chlorophenyl)methyl]thio]-4-pyrimidinol,**

10

Prepared by the method of example 4, step (a) and 3-chlorobenzylbromide.

MS: APCI 267 (M+H)

15

**(b) 6-chloro-2-[[[(3-chlorophenyl)methyl]thio]-4-pyrimidinamine**

Prepared by the method of example 4, step (b) using the product from example 11 step (a)

20

MS: APCI (+ve) 286 (M+H, 100 %)

**c) (2R)-2-[[6-amino-2-[[[(3-chlorophenyl)methyl]thio]-4-pyrimidinyl]amino]-1-propanol**

25

Prepared by the method of example 4, step (c) using the product of example 11, step (b)

MS: APCI (+ve) 325 (M+H, 100 %)

30

**d) (2R)-2-[[6-amino-2-[[[(3-chlorophenyl)methyl]thio]-5-nitroso-4-pyrimidinyl]amino]-1-propanol**

Prepared by the method of example 4, step (d) using the product of example 11, step (c).

MS: APCI (+ve) 354 (M+H, 100 %)

35

**(e) (2*R*)-2-[[5,6-diamino-2-[[3-chlorophenyl)methyl]thio]-4-pyrimidinyl]amino]-1-propanol**

Prepared by the method of example 4, step (e) using the product from example 11, step (d).

MS: APCI (+ve) 340 (M+H, 100 %)

**(f) [2-[[3-chlorophenyl)methyl]thio]-6-[[1*R*)-2-hydroxy-1-methylethyl]amino]-1*H*-purin-8-yl]-carbamic acid, ethyl ester**

Prepared by the method of example 4, step (f) using the product of example 11, step (e) (7.01g) to give the product as a peach coloured solid (2.20g).

MS: APCI (+ve) 437

<sup>1</sup>H NMR: δ (DMSO) 11.87 (1H, s), 11.43 (1H, s), 7.55-7.57 (1H, d), 7.49 (1H, s), 7.38-7.40 (1H,d), 7.33 (2H,m), 4.79-4.83 (1H,t), 4.33 (2H, s), 4.19-4.26 (1H+2H, m), 3.37-3.49 (2H, m), 1.25-1.29 (3H, t), 1.14-1.17 (3H, d).

**g) (2*R*)-2-[[8-amino-2-[[3-chlorophenyl)methyl]thio]-1*H*-purin-6-yl]amino]-1-propanol**

Prepared by the method of example 4, step (g) using the product of example 11, step (f) (0.25g) to give the product as a colourless solid (0.096g).

MS: APCI (+ve) 365

<sup>1</sup>H NMR: δ (DMSO) 7.47 (1H, s), 7.24-7.39 (3H, m), 6.65 (1H, br s), 6.51 (1H, br s), 4.77 (1H, br s), 4.26-4.36 (2H, t), 4.15 (1H, br s), 3.35-3.49 (2H, m), 1.11-1.13 (3H, d).

**Examples 12-20**

Examples 12 to 20 were prepared by first adding a solution of the appropriate benzyl halide ( $5 \times 10^{-6}$  mol) in THF to a solution of (2*R*)-2-[[8-amino-2-mercapto-1*H*-purin-6-yl]amino]-1-propanol ( $5 \times 10^{-6}$  mol) and sodium borohydride (large excess) in DMSO (0.1ml) and ethanol (0.1ml). The reaction mixture was allowed to stand overnight at room temperature.

The solvents were removed by evaporation and the resulting residue was taken up in dioxan (0.2ml) and water (0.1ml). To this a solution of lithium hydroxide monohydrate ( $4 \times 10^{-5}$  mol) in water (0.04ml) was added and the reaction mixture heated at 60°C for 22 hours. The mixture was neutralised with HCl, solvents removed by evaporation, and the residue was made up to a concentration of 10mmol using DMSO (0.5ml).

**(2R)-2-[(8-amino-2-mercapto-1H-purin-6-yl)amino]-1-propanol**

To a solution of the product from example 11, step (f) (760 mg) in liquid ammonia was added sodium metal until a consistent blue colour persisted. To this mixture was added powdered ammonium chloride until the blue colour had been quenched. The ammonia was allowed to evaporate and the residual solid was then dissolved in water (50 ml), filtered, then the pH adjusted to 6-7 by the addition of hydrochloric acid. The precipitated solid was then collected by filtration and dried in vacuo to give the subtitle compound (220 mg).

MS: APCI (+ve) 313 (M+H, 100 %)

**Example 12**

**(2R)-2-[[8-amino-2-[(phenylmethyl)thio]-9H-purin-6-yl]amino]-1-propanol**

MS: APCI (+ve) 331 (M+1).

**Example 13**

**(2R)-2-[[8-amino-2-[(3-methylphenyl)methyl]thio]-9H-purin-6-yl]amino]-1-propanol**

MS: APCI (+ve) 345 (M+1)

**Example 14**

**(2R)-2-[[8-amino-2-[(2-methylphenyl)methyl]thio]-9H-purin-6-yl]amino]-1-propanol**

MS: APCI (+ve) 345 (M+1)

**Example 15**

(2*R*)-2-[[8-amino-2-[[3-methoxyphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol

5

MS: APCI (+ve) 361 (M+1)

**Example 16**

10 (2*R*)-2-[[8-amino-2-[[4-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol

MS: APCI (+ve) 345 (M+1)

**Example 17**

15

(2*R*)-2-[[8-amino-2-[[2-bromophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol

MS: APCI (+ve) 411 (M+1)

20 **Example 18**

(2*R*)-2-[[8-amino-2-[[3-chloro-2-fluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol

25 MS: APCI (+ve) 383 (M+1)

**Example 19**

30 (2*R*)-2-[[8-amino-2-[[3-chloro-4-methoxyphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol

MS: APCI (+ve) 395 (M+1)

**Example 20**

35

**(2R)-2-[[8-amino-2-[(1,3-benzodioxol-4-ylmethyl)thio]-9H-purin-6-yl]amino]-1-propanol**

MS: APCI (+ve) 375 (M+1)

5

**Pharmacological Data**

**Ligand Binding Assay**

[<sup>125</sup>I]IL-8 (human, recombinant) was purchased from Amersham, U.K. with a specific  
10 activity of 2,000Ci/mmol. All other chemicals were of analytical grade. High levels of  
hrCXCR2 were expressed in HEK 293 cells (human embryo kidney 293 cells ECACC No.  
85120602) (Lee *et al.* (1992) *J. Biol. Chem.* **267** pp16283-16291). hrCXCR2 cDNA was  
amplified and cloned from human neutrophil mRNA. The DNA was cloned into PCRScript  
(Stratagene) and clones were identified using DNA. The coding sequence was sub-cloned  
15 into the eukaryotic expression vector RcCMV (Invitrogen). Plasmid DNA was prepared  
using Quiagen Megaprep 2500 and transfected into HEK 293 cells using Lipofectamine  
reagent (Gibco BRL). Cells of the highest expressing clone were harvested in phosphate-  
buffered saline containing 0.2%(w/v) ethylenediaminetetraacetic acid (EDTA) and  
centrifuged (200g, 5min.). The cell pellet was resuspended in ice cold homogenisation  
20 buffer [10mM HEPES (pH 7.4), 1mM dithiothreitol, 1mM EDTA and a panel of protease  
inhibitors (1mM phenyl methyl sulphonyl fluoride, 2µg/ml soybean trypsin inhibitor, 3mM  
benzamidine, 0.5µg/ml leupeptin and 100µg/ml bacitracin)] and the cells left to swell for  
10 minutes. The cell preparation was disrupted using a hand held glass mortar/PTFE pestle  
homogeniser and cell membranes harvested by centrifugation (45 minutes, 100,000g, 4°C).  
25 The membrane preparation was stored at -70°C in homogenisation buffer supplemented  
with Tyrode's salt solution (137mM NaCl, 2.7mM KCl, 0.4mM NaH<sub>2</sub>PO<sub>4</sub>), 0.1%(w/v)  
gelatin and 10%(v/v) glycerol.

All assays were performed in a 96-well MultiScreen 0.45µm filtration plates (Millipore,  
30 U.K.). Each assay contained ~50pM [<sup>125</sup>I]IL-8 and membranes (equivalent to ~200,000  
cells) in assay buffer [Tyrode's salt solution supplemented with 10mM HEPES (pH 7.4),  
1.8mM CaCl<sub>2</sub>, 1mM MgCl<sub>2</sub>, 0.125mg/ml bacitracin and 0.1%(w/v) gelatin]. In addition, a  
compound of formula (I) according to the Examples was pre-dissolved in DMSO and  
added to reach a final concentration of 1%(v/v) DMSO. The assay was initiated with the  
35 addition of membranes and after 1.5 hours at room temperature the membranes were  
harvested by filtration using a Millipore MultiScreen vacuum manifold and washed twice

with assay buffer (without bacitracin). The backing plate was removed from the MultiScreen plate assembly, the filters dried at room temperature, punched out and then counted on a Cobra  $\gamma$ -counter.

- 5 The compound of formula (I) according to the Examples was found to have  $IC_{50}$  values of less than ( $<$ )  $10\mu M$ .

#### **Intracellular Calcium Mobilisation Assay**

- Human neutrophils were prepared from EDTA-treated peripheral blood, as previously  
10 described (Baly *et al.* (1997) *Methods in Enzymology* 287 pp70-72), in storage buffer [Tyrode's salt solution (137mM NaCl, 2.7mM KCl, 0.4mM  $NaH_2PO_4$ ) supplemented with 5.7mM glucose and 10mM HEPES (pH 7.4)].

- The chemokine  $GRO\alpha$  (human, recombinant) was purchased from R&D Systems  
15 (Abingdon, U.K.). All other chemicals were of analytical grade. Changes in intracellular free calcium were measured fluorometrically by loading neutrophils with the calcium sensitive fluorescent dye, fluo-3, as described previously (Merritt *et al.* (1990) *Biochem. J.* 269, pp513-519). Cells were loaded for 1 hour at  $37^\circ C$  in loading buffer (storage buffer with 0.1%(w/v) gelatin) containing  $5\mu M$  fluo-3 AM ester, washed with loading buffer and  
20 then resuspended in Tyrode's salt solution supplemented with 5.7mM glucose, 0.1%(w/v) bovine serum albumin (BSA), 1.8mM  $CaCl_2$  and 1mM  $MgCl_2$ . The cells were pipetted into black walled, clear bottom, 96 well micro plates (Costar, Boston, U.S.A.) and centrifuged (200g, 5 minutes, room temperature).

- 25 A compound of formula (I) according to the Examples was pre-dissolved in DMSO and added to a final concentration of 0.1%(v/v) DMSO. Assays were initiated by the addition of an  $A_{50}$  concentration of  $GRO\alpha$  and the transient increase in fluo-3 fluorescence ( $\lambda_{Ex}$  = 490nm and  $\lambda_{Em}$  = 520nm) monitored using a FLIPR (Fluorometric Imaging Plate Reader, Molecular Devices, Sunnyvale, U.S.A.).

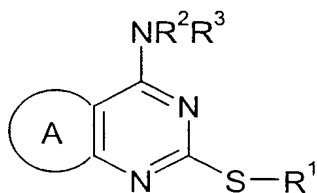
30

The compounds of formula (I) according to the Examples were tested and found to be antagonists of the CXCR2 receptor in human neutrophils.



## CLAIMS

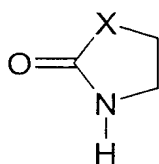
1. A compound of formula (I) and pharmaceutically acceptable salts or solvates thereof:



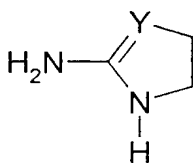
(I)

in which:

A is a group of formula (a) or (b):



(a)



(b)

- 15 R<sup>1</sup> represents a C<sub>3</sub>-C<sub>7</sub> carbocyclic, C<sub>1</sub>-C<sub>8</sub> alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl or C<sub>2</sub>-C<sub>6</sub> alkynyl group, the latter four groups may be optionally substituted by one or more substituent groups independently selected from halogen atoms, -OR<sup>4</sup>, -NR<sup>5</sup>R<sup>6</sup>, -CONR<sup>5</sup>R<sup>6</sup>, -COOR<sup>7</sup>, -NR<sup>8</sup>COR<sup>9</sup>, -SR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, -SO<sub>2</sub>NR<sup>5</sup>R<sup>6</sup>, -NR<sup>8</sup>SO<sub>2</sub>R<sup>10</sup>, an aryl or heteroaryl group either of which can be optionally substituted by one or more substituents independently selected
- 20 from halogen atoms, cyano, nitro, -OR<sup>4</sup>, -NR<sup>5</sup>R<sup>6</sup>, -CONR<sup>5</sup>R<sup>6</sup>, -COOR<sup>7</sup>, -NR<sup>8</sup>COR<sup>9</sup>, -SR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, -SO<sub>2</sub>NR<sup>5</sup>R<sup>6</sup>, -NR<sup>8</sup>SO<sub>2</sub>R<sup>10</sup>, C<sub>1</sub>-C<sub>6</sub> alkyl or trifluoromethyl groups;

R<sup>2</sup> and R<sup>3</sup> each independently represent hydrogen, a C<sub>3</sub>-C<sub>7</sub> carbocyclic group,

C<sub>1</sub>-C<sub>8</sub> alkyl, C<sub>2</sub>-C<sub>6</sub> alkenyl or C<sub>2</sub>-C<sub>6</sub> alkynyl group, the latter four groups may be optionally substituted by one or more substituent groups independently selected from halogen atoms, -OR<sup>4</sup>, -NR<sup>5</sup>R<sup>6</sup>, -CONR<sup>5</sup>R<sup>6</sup>, -COOR<sup>7</sup>, -NR<sup>8</sup>COR<sup>9</sup>, -SR<sup>10</sup>, -SO<sub>2</sub>R<sup>10</sup>, -SO<sub>2</sub>NR<sup>5</sup>R<sup>6</sup>, -NR<sup>8</sup>SO<sub>2</sub>R<sup>10</sup>

5 or

a 3-8 membered ring optionally containing one or more atoms selected from O, S, NR<sup>8</sup> and itself optionally substituted by C<sub>1-3</sub>-alkyl, halogen,

10 R<sup>4</sup> represents hydrogen, C<sub>1</sub>-C<sub>6</sub> alkyl or a phenyl group the latter two of which may be optionally substituted by one or more substituent groups independently selected from halogen atoms, phenyl, -OR<sup>11</sup> and -NR<sup>12</sup>R<sup>13</sup>;

15 R<sup>5</sup> and R<sup>6</sup> independently represent a hydrogen atom or a C<sub>1</sub>-C<sub>6</sub> alkyl or phenyl group the latter two of which may be optionally substituted by one or more substituent groups independently selected from halogen atoms, phenyl, -OR<sup>14</sup> and -NR<sup>15</sup>R<sup>16</sup>, -CONR<sup>15</sup>R<sup>16</sup>, -NR<sup>15</sup>COR<sup>16</sup>, -SO<sub>2</sub>NR<sup>15</sup>R<sup>16</sup>, NR<sup>15</sup>SO<sub>2</sub>R<sup>16</sup>

or

20 R<sup>5</sup> and R<sup>6</sup> together with the nitrogen atom to which they are attached form a 4- to 7-membered saturated heterocyclic ring system optionally comprising a further heteroatom selected from oxygen and nitrogen atoms, which ring system may be optionally substituted by one or more substituent groups independently selected from phenyl, -OR<sup>14</sup>, -COOR<sup>14</sup>, -NR<sup>15</sup>R<sup>16</sup>, -CONR<sup>15</sup>R<sup>16</sup>, -NR<sup>15</sup>COR<sup>16</sup>, -SO<sub>2</sub>NR<sup>15</sup>R<sup>16</sup>, NR<sup>15</sup>SO<sub>2</sub>R<sup>16</sup> or C<sub>1</sub>-C<sub>6</sub> alkyl, itself optionally substituted by one or more substituents independently selected from halogen atoms and -NR<sup>15</sup>R<sup>16</sup> and -OR<sup>17</sup> groups;

25

R<sup>10</sup> represents a C<sub>1</sub>-C<sub>6</sub> alkyl group or phenyl group, each of which may be optionally substituted by one or more substituent groups independently selected from halogen atoms, phenyl, -OR<sup>17</sup> and -NR<sup>15</sup>R<sup>16</sup>;

30 X is NH or CR<sup>18</sup>R<sup>19</sup>;

Y is N or CR<sup>18</sup>; and

35 each of R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup>, R<sup>11</sup>, R<sup>12</sup>, R<sup>13</sup>, R<sup>14</sup>, R<sup>15</sup>, R<sup>16</sup>, R<sup>17</sup>, R<sup>18</sup>, R<sup>19</sup> independently represent a hydrogen atom, C<sub>1</sub>-C<sub>6</sub>, alkyl, or a phenyl group.

2. A compound according to claim 1, wherein A is a group of formula (b) and Y is N.
3. A compound according to claim 1 or claim 2, wherein R<sup>1</sup> represents an optionally  
5 substituted benzyl group.
4. A compound according to claim 1, 2 or 3, wherein one of R<sup>2</sup> and R<sup>3</sup> is hydrogen and the other is C<sub>3</sub>-C<sub>8</sub> alkyl substituted by one or more hydroxy groups.
- 10 5. A compound according to claim 1 selected from:  
2-[(2,3-Difluorophenyl)methyl]thio]-5,7-dihydro-4-[(1*R*)-2-hydroxy-1-methylethyl]amino]- 6*H*-pyrrolo[2,3-*d*]pyrimidin-6-one,  
7,9-dihydro-6-[(1*R*)-2-hydroxy-1-methylethyl]amino]-2-[(phenylmethyl)thio]-8*H*-purin-8-one,  
15 4-amino-2-[(2,3-difluorophenyl)methyl]thio]-5,7-dihydro-6*H*-pyrrolo[2,3-*d*]pyrimidin-6-one,  
(2*R*)-2-[[8-amino-2-[(2-fluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1,3-propanediol,  
2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-2-methyl-1-  
20 propanol,  
(2*R*)-2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-butanol,  
2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-2-methyl-1,3-propanediol,  
(2*R*)-2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
25 2-[[8-amino-2-[(2,3-difluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-ethanol,  
(2*R*)-2-[[8-amino-2-[(3-chlorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
(2*R*)-2-[[8-amino-2-[(phenylmethyl)thio]-9*H*-purin-6-yl]amino]-1-propanol,  
(2*R*)-2-[[8-amino-2-[(3-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
(2*R*)-2-[[8-amino-2-[(2-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
30 (2*R*)-2-[[8-amino-2-[(3-methoxyphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
(2*R*)-2-[[8-amino-2-[(4-methylphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,  
(2*R*)-2-[[8-amino-2-[(2-bromophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

(2*R*)-2-[[8-amino-2-[[[(3-chloro-2-fluorophenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

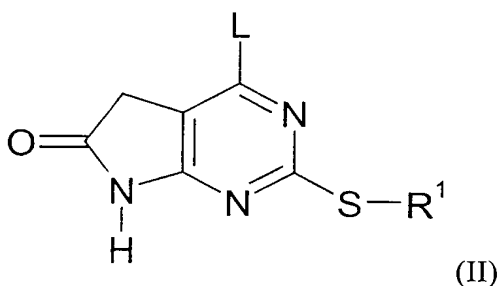
(2*R*)-2-[[8-amino-2-[[[(3-chloro-4-methoxyphenyl)methyl]thio]-9*H*-purin-6-yl]amino]-1-propanol,

5 (2*R*)-2-[[8-amino-2-[(1,3-benzodioxol-4-ylmethyl)thio]-9*H*-purin-6-yl]amino]-1-propanol, and their pharmaceutically acceptable salts and solvates.

6. A process for the preparation of a compound of formula (I) as defined in claim 1 which comprises:-

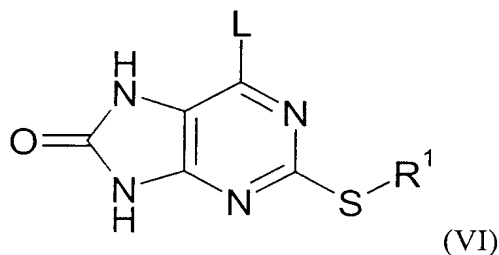
10

(a) treatment of a compound of formula (II):



15 where R<sup>1</sup> is as defined in formula (I) and L is a leaving group with an amine HNR<sup>2</sup>R<sup>3</sup> or

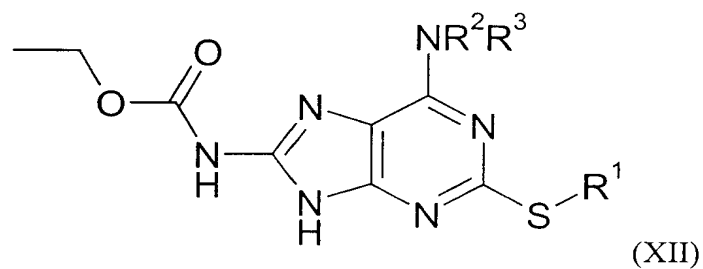
(b) treatment of a compound of formula (VI):



20

where R<sup>1</sup> is as defined in formula (I) and L is a leaving group with an amine HNR<sup>2</sup>R<sup>3</sup> or

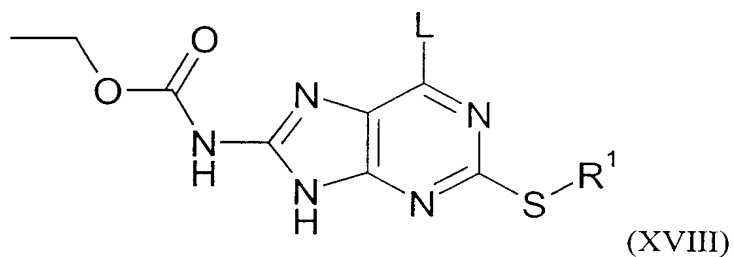
(c) treatment of a compound of formula (XII):



where  $R^1$ ,  $R^2$  and  $R^3$  are as defined in formula (I) with a hydrolysing agent such as lithium hydroxide, or

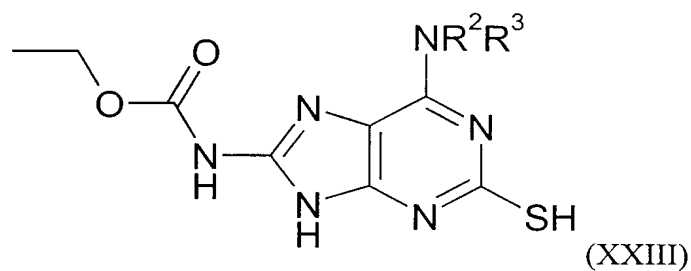
5

(d) treatment of a compound of formula (XVIII):



10 where  $R^1$  is as defined in formula (I) and L is a leaving group with an amine  $\text{HNR}^2\text{R}^3$ , or

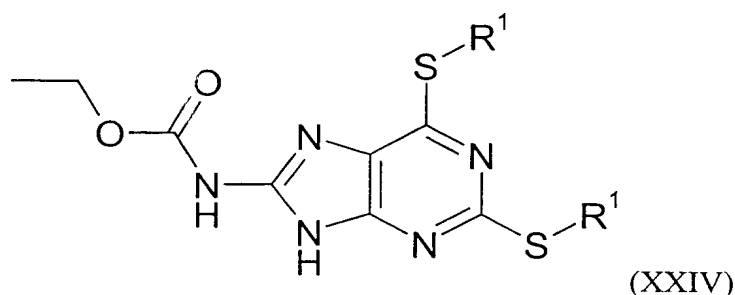
(e) treatment of a compound of formula (XXIII):



15

where  $R^2$  and  $R^3$  are as defined in formula (I) with an alkyl halide  $\text{R}^1\text{X}$ , or

(f) treatment of a compound of formula (XXIV):



where R¹ is as defined in formula (I) with an amine HNR²R³, and optionally thereafter (a),  
5 (b), (c), (d), (e) or (f) forming a pharmaceutically acceptable salt.

7. An intermediate compound of formula (II), (VI), (XII), (XVIII), (XXIII) or (XXIV) as defined in claim 6.
- 10 8. A pharmaceutical composition comprising a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as claimed in any one of claims 1 to 5 in association with a pharmaceutically acceptable adjuvant, diluent or carrier.
9. A process for the preparation of a pharmaceutical composition as claimed in claim 8  
15 which comprises mixing a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as claimed in any one of claims 1 to 5 with a pharmaceutically acceptable adjuvant, diluent or carrier.
10. A compound of formula (I), or a pharmaceutically-acceptable salt or solvate thereof, as  
20 claimed in any one of claims 1 to 5 for use in therapy.
11. Use of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as claimed in any one of claims 1 to 5 in the manufacture of a medicament for use in therapy.
- 25 12. A method of treating a chemokine mediated disease wherein the chemokine binds to one or more chemokine receptors, which comprises administering to a patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as claimed in any one of claims 1 to 5.

13. A method according to claim 12 in which the chemokine receptor belongs to the CXC chemokine receptor subfamily.
14. A method according to claim 12 or 13 in which the chemokine receptor is the CXCR2  
5 receptor.
15. A method of treating an inflammatory disease in a patient suffering from, or at risk of, said disease, which comprises administering to the patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate  
10 thereof, as claimed in any one of claims 1 to 5.
16. A method according to claim 15, wherein the disease is psoriasis, a disease in which angiogenesis is associated with raised CXCR2 chemokine levels, or COPD.
- 15 17. A method according to claim 15, wherein the disease is psoriasis.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00245

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C07D 487/04, A61K 31/519, A61P 11/00, A61P 17/06, A61P 29/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C07D, A61K, A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,N0 classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| X          | Chemical Abstracts, Volume 54, No 10, May 1960,<br>ABSTRACT No. 9933f, C Wayne Noell and Roland K.<br>Robins, "Potential purine antagonists XVII.<br>Synthesis of 2-methyl and 2-methylthio-6,<br>8-disubstituted purines", see formula III when<br>R=SMe, R1=Cl, R2= OH<br><br>-- | 7                     |
| X          | EP 0778277 A1 (PFIZER INC.), 11 June 1977<br>(11.06.77), see claims 1 and 18<br><br>--   | 1-17                  |
| X          | WO 9808847 A1 (PFIZER INC.), 5 March 1998<br>(05.03.98), see claims 1 and 16-19<br><br>--  | 1-17                  |

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

18 June 2001

Date of mailing of the international search report

25 -06- 2001

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00245

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                           | Relevant to claim No. |
|-----------|--|-----------------------|
| X         | WO 9951608 A1 (DU PONT PHARMACEUTICALS COMPANY),<br>14 October 1999 (14.10.99), see claims 1 and 5<br><br>-- | 1-17                  |
| P,X       | WO 0009511 A1 (ASTRA PHARMACEUTICALS LTD.),<br>24 February 2000 (24.02.00), see whole document<br><br>--     | 1-17                  |
| A         | WO 9825617 A1 (MERCK & CO. INC.), 18 June 1998<br>(18.06.98), see claim 8<br><br>--<br>-----                 | 1-17                  |

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE01/00245

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: **12-17**  
because they relate to subject matter not required to be searched by this Authority, namely:  
**see next sheet**
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE01/00245

Claims 12-17 relate to methods of treatment of the human or animal body by surgery or by therapy/ diagnostic methods practised on the human or animal body/Rule 39.1.(iv). Nevertheless, a search has been executed for these claims. The search has been based on the alleged effects of the compounds/compositions.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

28/05/01

International application No.

PCT/SE 01/00245

| Patent document<br>cited in search report |          |    | Publication<br>date | Patent family<br>member(s) |              | Publication<br>date |
|---|----------|----|---------------------|----------------------------|--------------|---------------------|
| EP  | 07782777 | A1 | 11/06/77            | NONE                       |              |                     |
| WO  | 9808847  | A1 | 05/03/98            | AP                         | 762 A        | 13/09/99            |
|   |          |    |                     | AP                         | 9701077 D    | 00/00/00            |
|   |          |    |                     | AU                         | 3456197 A    | 19/03/98            |
|   |          |    |                     | BG                         | 103189 A     | 30/09/99            |
|   |          |    |                     | BR                         | 9711970 A    | 24/08/99            |
|   |          |    |                     | CN                         | 1227554 A    | 01/09/99            |
|   |          |    |                     | CZ                         | 9900681 A    | 17/11/99            |
|   |          |    |                     | EP                         | 0923582 A    | 23/06/99            |
|   |          |    |                     | HR                         | 970454 A     | 31/08/98            |
|   |          |    |                     | HU                         | 9903965 A    | 28/03/00            |
|   |          |    |                     | IL                         | 127566 D     | 00/00/00            |
|   |          |    |                     | JP                         | 2000502723 T | 07/03/00            |
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